Mesoscale Analysis and Forecasting

1a. Draw conclusions about non-convective severe weather phenomena.

Precipitation

- To forecast precipitation, you must forecast temperature, atmospheric stability, availability of moisture, and cloud types

Precipitation

- Forecasting precipitation type largely dependent on the height of the freezing level(s) and the depth of the warm layer aloft
  - Single freezing level
    - If the freezing level closest to the surface is ≥ 1,200 feet AGL, forecast liquid precipitation

Precipitation

- If the freezing level closest to the surface is ≤ 600 feet AGL, forecast solid precipitation
- If the freezing level closest to the surface is between 600 feet and 1,200 feet AGL, forecast mixed precipitation
- The freezing levels can be determined from Skew-T, the radar bright band on the RHI scope,

Single Freezing level greater than or equal to 1,20

Single Freezing level level less than or equal to 60

Single Freezing level greater than 600 feet and less than

Precipitation

- Multiple freezing levels is when there are two cold layers with a warm, melting layer in between
  - If the warm layer is > 1,200 feet thick, forecast freezing rain (cold rain process)
  - If the warm layer is between 600-1,200 feet, forecast ice pellets (cold rain process)

Multiple Freezing Level – Freezing Rain

Multiple Freezing Level – Freezing Rain/ Ice pelle

Precipitation

- If the cold layer closest to the surface is ≤ 1,500 feet, forecast freezing rain; forecast ice pellets with a cold layer > 1,500 feet

Precipitation

- Melting (warm) layer maximum temperature
  - Whether complete melting will occur in a warm layer or not depends on many variables (e.g., crystal size, depth of warm layer, temperature within the warm layer, among others)
  - Most snowflakes melt completely with maximum temperature in the warm layer between 1°C and 4°C

Precipitation

- If the max temperature in the warm layer is between these specified temperatures, forecast freezing rain; if not, forecast ice pellets or snow

Precipitation

- Freezing precipitation types
  - Freezing rain
    - It is rain that falls in liquid form but freezes upon impact to form a coating or glaze upon the ground and on exposed objects
    - It is necessary that the liquid drops be supercooled before striking the ground
    - Freezing rain, when encountered by aircrafeet in flight, can cause dangerous accumulation of clear icing

Precipitation

- Freezing drizzle
  - It is drizzle that falls in liquid form but freezes upon impact to form a coating of glaze upon the ground and on exposed objects
  - It is necessary that the liquid drops be supercooled before striking the ground
  - Freezing drizzle, when encountered by aircrafeet in flight, can cause dangerous accumulation of mixed icing

Precipitation

- Freezing precipitation synoptic patterns
  - The basic conditions necessary are shallow layer of sub-freezing air near the surface with warmer, moist air overriding it
  - Frontal systems
    - Warm front is the ideal situation which produces most widespread episodes of freezing precipitation

Precipitation

- Stationary frontal boundary produces freezing precipitation where moist air overrunning an arctic or polar air mass
- Cold front produces freezing precipitation where a continental polar/arctic air mass wedges under warmer moist air

Precipitation

- Other types of precipitation
  - Ice pellets
    - This precipitation falls in the solid form
    - This type must have a deep cold pocket near the surface
    - A warm pocket alofeet 600 to 1,200 feet thick.

Precipitation

- As partially melted snow falls into the cold air, it totally refreezes into ice pellets
- Usually occurs in narrow zones between areas of freezing precipitation and snow

Precipitation

- Rain may occur with either warm or cold rain process
  - Warm rain - entire cloud is at temperatures above 0°C
  - Cold rain - cloud and precipitation occur partially at temperatures below 0°C

Precipitation

- Method of forecasting freezing precipitation
  - Surface and 850-mb isotherm pattern
    - To initially determine precipitation type, the 850-mb 0°C and 32°F isotherms are good guidelines
    - By using the 32°F isotherm as a base, the placement of the 850-mb 0°C, with respect to the base, is a good starting point

Sfc/850 mb Isotherm Pattern

Precipitation

- When the 850-mb 0°C isotherm is on the cold (north) side of the surface 32°F isotherm (base), forecast freezing precipitation or ice pellets
- When the 850-mb 0° C isotherm is on the warm (south) side of the base, forecast wet snow and/or mixed precipitation
- East of the Appalachian Mountains, use the 850-mbs 2°C isotherm instead of 0°C

Precipitation

- Thickness isopleth analysis is a good tool to forecast types of precipitation during the winter
  - 1000-500-mb thickness
    - Easiest chart to use; delineates between liquid and solid precipitation
    - 5,400 meter isopleth - threshold value which delineates between liquid (on the warm side) and solid (on the cold side) precipitation

1000-500 mb Threshold values

Precipitation

- Be aware: the 5,400 meter isopleth is most representative over the midwest and northern plains; higher thickness value thresholds exist over the mountains, lower thresholds near the coastlines
- Use figure 8, Section 2.4.2.1 of AF Pamphlet 105-56 to forecast liquid versus solid precipitation for areas other than the Midwest and Northern Plains
- Freezing Precipitation - forecast between the 5,400 and 5,520 meter thickness isopleths where surface temperatures are ≤ 32ºF

1000-500 mb thickness/Freezing Precip

Precipitation

- Low-level thickness (LLT) (1000-850 mb)
  - Compute by subtracting the 1000 mb from the 850-mb height
  - Then determine the location of the 1,300 meter isopleth, which is the low-level thickness threshold value

Precipitation

- Mid-level thickness (MLT) (850-700 mb)
  - Compute by subtracting the 850-mb height from the 700-mb height
  - Determine the locations of the 1,520, 1,540, and the 1,555 meter isopleths
  - The 1,555 meter isopleth is the threshold value for mid-level thickness

Precipitation

- Low-level/mid-level thickness composite chart is the tool used to perform an analysis for precipitation types
  - 1 Forecast snow or snow showers between the 1,520 and 1,540m MLT isopleths and on the cold (north) side of the 1,300m LLT isopleth
  - 2 Forecast heavy snow in the same area between the 700 mb -10ºC and the 850 mb -5ºC T_d and on the cold side of the 850 mb 0ºC

Precipitation

- Forecast freezing precipitation between the 1,540 and 1,555 m MLT isopleths, and on the cold side of the 1,300 m LLT isopleth
- Forecast light, patchy freezing precipitation on the warm side of the 1,555 m MLT isopleth, but on the cold side of the 1,300 m LLT isopleth and surface 32°F isotherm

Precipitation

- Snow Index uses the 1000 mb to 700-mb thickness.
- Equation: $y + 2x = 4{,}179$ meters
  - If the answer is greater than 4,179 meters - liquid
  - If the answer is equal to 4,179 meters - mixed
  - If the answer is less than 4,179 meters - snow

Heavy snow

- Heavy snow is the accumulation of $\geq$ 2 inches in a 12-hour period
- Determining the location of heavy snow
  - Surface analysis (low-pressure center)
    - Heavy snow occurs on the cold side of the 0°C isotherm

Heavy snow Sfc Analysis

Heavy snow

- It can be up to 2.5° latitude to the left of the track of the occluded and/or non-occluded low and up to 5° latitude downstream

Heavy snow

- 850-mb analysis (low-height center)
  - Heavy snow occurs on the cold side of the 0°C isotherm (-2°C east coast US) where the dew points are between 0°C and -5°C
  - It can be anywhere from 1 to 4° latitude to the left of the track, from 3 to 12° latitude downstream of the low

Heavy snow 850 mb analysis

Heavy snow

- The 850-mb -5°C isotherm ofeeten bisects the area of the heaviest snow in the following 12-hour period

Heavy snow

- 700-mb analysis (low-height center/trough)
  - Heavy snow occurs on the cold side of the -6°C isotherm where the dew points are between -6°C and -10°C
  - Heavy snow occurs along the track of the 700-mb low
  - Snow usually begins with passage of the 700-mb ridges

Heavy snow 700 mb analysis

Heavy snow

- Heavy snow usually ends with the passage of the 700-mb trough or low center

Heavy snow

- 500-mb analysis (low-height center/trough)
  - Heavy snow occurs on the cold side of the -35°C isotherm if located north of 40°N
  - Heavy snow occurs on the cold side of the -25°C isotherm if located south of 40°N
  - Heavy Snow occurs along the track of the 500-mb low

Heavy snow 500 mb analysis

Heavy snow

- It can be up to 2.5° latitude to the lefeet of the track of the 500-mb vorticity maximum and up to 6.5 to 7° latitude downstream
- Heavy snow can be to the left of the track of the 500-mb height fall center and slightly downstream from the inflection point between the trough and downstream ridge
- Snow usually ends with the passage of the 500-mb trough, vorticity max, or low center

Heavy snow

- Average humidity/maximum wind analysis
  - The area where the surface to 500-mb average relative humidity $\geq$ 70%
  - The area where the 850 mb and 500-mb max wind bands intersect

Heavy snow Avg RH and 850/500 mb Max wind b

Heavy snow

- Heavy snow usually occurs along the thickness ridge (1000/500-mb thickness) between the 5,310 and 5,370-meter thickness lines

Heavy snow

- Synoptic situations that produce heavy snow
  - Baroclinic non-occluding low
    - This system usually tracks to the east-northeast at approximately ≥ 25 knots
    - Usually associated with a fast moving trough at 500 mb

Baroclinic non-occluding low

Heavy snow

- Area of maximum snowfall
  - Lies left of the surface low oriented parallel to the track of the low
  - The southern edge of the max snowfall is located about 60 nm (1° latitude) to the left of the storm track
  - The width of the snow band is about 100-200 nm
  - The snowfall rate: ≥ 1 inch/hour lasting 4 to 8 hours

Heavy snow

- Baroclinic deep-occluding low (blizzard type)
  - The most dangerous type of winter storm is associated with weather that includes
    - winds $\geq$ 40 knots, temperatures $\leq$ 20°F
    - visibilities that have been drastically reduced by blowing and/or falling snow
    - A severe blizzard contains winds $\geq$ 50 knots and temperatures $\leq$ 10°F

Baroclinic Occluding Low

Heavy snow

- This system features a deep occluding low with a downstream, wraparound ridge that is oriented NW-SE (Type B occlusion)
- Associated with a closed, cold core low at 500 mb
- This system usually tracks to the north-northeast, slowing to approximately 5 to 10 knots

Heavy snow

- Area of maximum snowfall
  - Lies to the left and parallel to the track of the surface low
  - Snowfall rates 1 to 2 inches/hour lasting up to 10 hours, with the length of duration variable
  - The western edge of the heavy snow area is the 700-mb low and/or trough axis, with most of the snow usually ending with the passage of the 500-mb trough

Heavy snow

- If short waves continue to develop and propagate around the upper-level low, this system becomes highly susceptible to secondary development, especially along the east coasts of continents

Heavy snow

- Post-cold frontal trough
  - Associated with a steep cold front oriented in a deep long-wave trough
  - Minor wave forms on the front and moves northward along the front
  - Strong cold-air advection from the surface to 850 mb exists to the west of the front

Post cold frontal trough

Heavy snow

- Sharp amplitude short-wave troughs at 700 and 500 mb lie about 200 to 300 nm to the west of the surface front
- Area of maximum snowfall
  - Located between the 850-mb and 700-mb short wave troughs
  - The area usually generates and dissipates in 12 to 18 hours with the heavy snow lasting only 2 to 4 hours

Heavy snow

- Warm advection
  - There is no active low pressure center in the vicinity of the maximum snow area
  - A persistent high pressure ridge is situated to the north-northeast of a quasi-stationary front
  - A well developed low-level flow (850 mb) of moist air is overrunning the frontal surface

Warm advection

Heavy snow

- Area of maximum snowfall
  - Located in a band parallel to and just north of the quasi-stationary surface front
  - Moderate to heavy snow usually lasts 6-12 hours
  - If the warm front begins to move, expect a change from snow to freezing rain and then to rain due to the advection of warmer, low-level air

Heavy snow

- Inverted trough
  - Inverted trough extends northward from a closed low pressure system
  - Easterly component of low-level flow produces overrunning of the inverted trough as well as an upslope condition
  - All snowfall usually ends with the passage of the 700-mb trough

Inverted Trough

Heavy snow

- Heavy snow is produced when the 500-mb flow is parallel to the surface inverted trough
- Area of maximum snowfall
  - Located within and on either side of the inverted surface trough
  - Amounts depend on the moisture supply, winds, and speed of movement of the troughs

Heavy snow

- 200-mb snow index heavy snow forecasting technique
  - The technique is used to forecast the maximum snowfall amount and area
  - It uses the warm sink associated with a well-developed baroclinic low

200 mb Index snow amount

Heavy snow

- Procedure
  - To forecast the snowfall amount, an index for average snowfall (in inches) for the following 24 hours can be calculated
    - Determine the 200-mb temperature at your station
    - Find the 200-mb warm pocket that is located between 6° and 14° latitude upstream of your station

Heavy snow

- Determine the amount of warm-air advection that is occurring between the warm pocket and your station
- Take 1/2 of this indicated temperature change (ΔT) to determine the amount of snowfall
- **IR:**

Heavy snow

- Forecasting snowfall area
  - The area of maximum snow will be near the coldest 200-mb temperatures downstream from the 200-mb warm pocket (sink)
  - This area will be parallel to the 200-mb contours, with the width being the same as the distance between adjacent contours
  - The southwestern end of the maximum snow area is the warm sink and the northeastern end being the eastern edge of the cold pocket (dome)

200 mb Index snow area

Heavy snow

- To forecast where the point of maximum snowfall will be, use the following guidelines:
- For a 24-hour forecast, look 14° latitude downstream from the 200-mb warm sink
- For a 36-hour forecast look 21° latitude downstream from the 200-mb warm sink
- **IR:**

Heavy snow

- Weaknesses:
  - Do not forecast heavy snow beneath strong confluence at 200 mb
  - The heavy snow area will be to the south of this area
  - Do not forecast heavy snow south of the surface lows

Heavy snow

- With a northwesterly flow aloft, systems move rapidly and generally < 2 inches of snow will fall
- 700-mb warm air advection into threat area is essential; if cold air advection occurs into threat area, forecast snow amounts of 1/4 the indicated warm air advection at 200 mbs.

Heavy snow

Downslope wind storms

- These are severe downslope wind storm having maximum gusts greater than 64 knots and mean wind speeds greater than 32 knots which persists for at least one hour

Downslope wind storms

- Fall/glacier wind is caused by differential heating/cooling associated with snow and/or ice covered mountains or a glacier
  - Temperature over the snow and/or glacier is 25°F to 50°F colder than the surrounding air

Fall/Glacier wind

Downslope wind storms

- The cold dense air descends the mountain/glacier rapidly
- This causes the surface temperatures, below the mountain/glacier, to cool by at least 20°
  - This descending air is initially cold and remains cold despite adiabatic warming

Downslope wind storms

- This cold dense air will flow down the mountain/glacier as a dry wind and will remain as such

  - This wind is NOT diurnally dependent
  - Therefore, this condition may occur day or night

Downslope wind storms

- Indicators of a severe version of the Chinook
  - Winds W-NW at all levels above the mountain tops (in North America)
  - Winds within 45˚ of perpendicular to the mountain range
  - A strong NVA field (vorticity decreasing 6 isopleth values or more in 12 hours)

Chinook

Downslope wind storms

- Strong WAA at the 700 & 500-mb levels (temperature increasing 6°C or more in 12 hours) in conjunction with a strong upper-level subsidence field
- Surface pressure falls east of the mountain range (falls $\geq$ 1mb/hr); this is due to the strong adiabatic warming of this area

Downslope wind storms

- The strongest winds occur in the area of the maximum pressure falls
- This wind is NOT diurnally dependent
- Therefore, this condition may occur day or night

Downslope wind storms

- Indicators of a severe version of the Bora
  - Winds W-NW at all levels above the mountain tops
  - Winds within 45° of perpendicular to the mountain range

Bora

Downslope wind storms

- A strong PVA field (vorticity increasing 6 isopleth values or more in 12 hours)
- Strong CAA at the 700 & 500-mb levels (temperature decreasing 6°C or more in 12 hours)

Downslope wind storms

- Surface pressure rises on the leeside of the mountain range
- The strongest winds occur in the area of the maximum pressure rises

- APPLICATION: Students will complete appraisals and answer questions in class.
- EVALUATION: Written test at the end of the unit.